9. CAPITAL AND PRODUCTION COST AND ECONOMIC ANALYSIS

Capital cost, production cost, and cost-of-electricity estimates were developed for each plant based on adjusted vendor-furnished and actual cost data, and resulting in determination of a revenue requirement cost-of-electricity based on the power plant costs and assumed financing structure.

9.1 CAPITAL COSTS

The capital costs at the Total Plant Cost level include equipment, materials, labor, indirect construction costs, engineering, and contingencies. Operation and maintenance cost values were determined on a first-year basis and subsequently levelized over the 20-year plant book life to form a part of the economic analysis. Quantities for major consumables such as fuel and sorbent were taken from technology-specific heat and mass balance diagrams developed for each plant application. Other consumables were evaluated on the basis of the quantity required using reference data. Operation cost was determined on the basis of the number of operators. Maintenance costs were evaluated on the basis of requirements for each major plant section. The operating and maintenance costs were then converted to unit values of $/kW-year or ¢/kWh.

Each major component was based on a reference bottoms-up estimate, establishing a basis for subsequent comparisons and easy modification as the technology is further developed.

- Total Plant Cost, or "Overnight Construction Costs" values are expressed in January 1998 year dollars.
- Total Plant Investment values are expressed in mixed year dollars for a January 2005 commercial operation.
- The estimates represent commercial technology plants, or nth plants for the PC and NGCC and initial commercial offerings for the IGCC.
- The estimates represent a complete power plant facility, with the exception of the exclusions listed below.

- The estimate boundary limit is defined as the total plant facility within the "fence line," including coal receiving and water supply system but terminating at the high voltage side of the main power transformers.
- Site is characterized to be located in Middletown, USA. Although not specifically sited within any region, it is based on a relative equipment/material/labor factor of 1.0 and is considered to be located on a major navigable waterway.
- Costs are grouped according to a process/system oriented code of accounts; all reasonably allocable components of a system or process are included in the specific system account in contrast to a facility, area, or commodity account structure.
- The operating and maintenance expenses and consumable costs were developed on a quantitative basis.
- Operating labor cost was determined on the basis of the number of operators required.
- Maintenance cost was evaluated on the basis of relationships of maintenance cost to initial capital cost.
- Cost of consumables, including fuel, was determined on the basis of individual rates of consumption, the unit cost of each consumable, and the plant annual operating hours.
- Byproduct credits for commodities such as gypsum and emissions are not considered due to the variable marketability. However, credit for sulfuric acid is recognized in the economic evaluations.

Each of these expenses and costs is determined on a reference year basis and escalated to a first-year basis, and subsequently levelized over the life of the plant and reported on the 10^{th} year basis through application of a levelizing factor to determine the value that forms a part of the economic evaluation. This amount, when combined with fuel cost and capital charges, results in the figure-of-merit, COE.

The capital cost, specifically referred to as Total Plant Cost (TPC) for each power plant, was estimated for the categories consisting of bare erected cost, engineering and home office overheads, and fee plus contingencies. The TPC level of capital cost is the "overnight

construction" estimate. The capital cost was determined through the process of estimating the cost of every significant piece of equipment, component, and bulk quantity.

The capital cost is defined not only in terms of the TPC but also the categories Total Plant Investment (TPI), and Total Capital Requirement (TCR). Table 9-1 identifies the various cost elements that are included in each level of the capital cost.

Table 9-1
LEVELS OF CAPITAL COST

Bare Erected Cost (Process Capital and Facilities)
Equipment Cost
Material Cost
Direct Labor Cost
Indirect Labor Cost
Total Plant Cost (TPC)
Engineering
Contingencies
Process
Project
Total Plant Investment (TPI)
Cash Expended (Escalation)
AFDC
Total Capital Requirement (TCR)
Royalty
Preproduction Cost
Inventory Capital
Initial Catalyst and Chemicals
Land Cost

The reference labor cost to install the equipment and materials was estimated on the basis of labor man-hours. Labor costing was determined on a multiple contract labor basis with the labor cost including direct and indirect labor costs plus fringe benefits and allocations for contractor

expenses and markup. This was supplemented in limited cases, as required, with equipment labor relationship data to determine the labor cost.

The indirect labor cost was estimated at 7 percent of direct labor to provide the cost of construction services and facilities not provided by the individual contractors. The indirect cost represents the estimate for miscellaneous temporary facilities such as construction road and parking area construction and maintenance, installation of construction power; installation of construction water supply and general sanitary facilities, and general and miscellaneous labor services such as jobsite cleanup and construction of general safety and access items.

The TPC level of the estimate consists of the bare erected cost plus engineering and contingencies. The engineering costs represent the cost of architect/engineer (A/E) services for home office engineering, design, drafting, and project construction management services. The cost was determined at a nominal rate of 8 percent applied to the bare erected cost on an individual account basis. Any cost for engineering services provided by the equipment manufacturers and vendors is included directly in the equipment costs.

The TPC estimate summary at the major account level is shown on Table 9-2.

Consistent with conventional power plant practices, the general project contingency was added to the TPC to cover project uncertainty and the cost of any additional equipment that could result from a detailed design. This project contingency is intended to cover the uncertainty in the cost estimate itself. The contingencies represent costs that are expected to occur. Based on EPRI criterion 1, the cost estimate contains elements of Classes I, II, and III level estimates. As a result, on the basis of the EPRI guidelines, a variable rate was used to arrive at the plant nominal cost value. These values, at the stem account level, are included in Appendix E. This project contingency is intended to cover the uncertainty in the cost estimate itself. A similar approach was applied to recognize process contingency except only non-mature accounts have process contingency values. The contingencies represent costs that are expected to occur.

TABLE 9-2
CASE COMPARISON - COST DATA
Total Plant Cost (Jan., 1998 $)

Acct No.	Item/Description	Destec 2 "F"		Destec-"G"		Destec-"H"		Transport Gasifier		2gPFBCw/Boost	
		$x1,000	**$/kW**	**$x1,000**	**$/kW**	**$x1,000**	**$/kW**	**$x1,000**	**$/kW**	**$x1,000**	**$/kW**
1	COAL & SORBENT HANDLING	21,038	39	14,796	42	15,916	37	15,416	39	16,056	42
2	COAL & SORBENT PREP.& FEED	34,519	64	19,410	56	20,978	49	13,596	34	21,483	57
3	FW,COND.& MISC.SYS.	25,354	47	17,049	49	18,028	42	16,736	42	19,319	51
4	GASIFIER / BOILER & ACCESSORIES	225,411	415	125,137	358	142,768	334	70,400	177	62,345	164
5	GAS (HOT) CLEANUP & PIPING	69,948	129	52,084	149	55,737	130	77,179	194	37,405	99
6	COMBUSTION TURBINE/ACCESSORIES	82,767	152	58,088	166	60,143	141	60,143	151	77,014	203
7	HRSG, DUCTING & STACK	40,790	75	22,864	65	23,395	55	22,272	56	13,917	37
8	STEAM TURBINE GENERATOR	43,657	80	27,608	79	28,167	66	26,112	66	36,767	97
9	COOLING WATER SYSTEM	18,935	35	12,121	35	13,064	31	12,123	30	14,561	38
10	ASH/SPENT SORBENT HANDLING SYS	14,958	28	9,303	27	10,009	23	7,754	19	12,147	32
11	ACCESSORY ELECTRIC PLANT	49,660	91	32,323	93	34,285	80	21,892	55	24,946	66
12	INSTRUMENTATION & CONTROL	17,630	32	15,287	44	17,685	41	15,599	39	15,783	42
13	IMPROVEMENTS TO SITE	11,976	22	9,557	27	10,471	24	9,648	24	12,859	34
14	BUILDINGS & STRUCTURES	17,631	32	13,629	39	14,477	34	13,691	34	14,932	39
	TOTAL PLANT COST	**$674,276**	**1,241**	**$429,256**	**1,229**	**$465,125**	**1,087**	**$382,559**	**961**	**$379,535**	**1,001**

TABLE 9-2 (Cont'd)
CASE COMPARISON - COST DATA
Total Plant Cost (Jan., 1998 $)

Acct		Subcritical PC		Supercritical PC		Ultracritical PC		NGCC-"G"		NGCC-"H"	
No.	Item/Description	**$x1,000**	**$/kW**	**$x1,000**	**$/kW**	**$x1,000**	**$/kW**	**$x1,000**	**$/kW**	**$x1,000**	**$/kW**
1	COAL & SORBENT HANDLING	19,134	48	18,560	46	18,095	45				
2	COAL & SORBENT PREP.& FEED	15,201	38	14,613	36	14,326	36				
3	FW,COND.& MISC.SYS.	31,276	79	32,304	80	33,059	83	14,891	46	15,922	40
4	GASIFIER / BOILER & ACCESSORIES	85,639	215	106,879	266	104,861	262				
5	GAS (HOT) CLEANUP & PIPING	64,146	161	63,314	158	61,621	154				
6	COMBUSTION TURBINE/ACCESSORIES							51,315	157	53,907	136
7	HRSG, DUCTING & STACK	22,293	56	21,583	54	20,925	52	21,770	67	22,986	58
8	STEAM TURBINE GENERATOR	66,916	168	70,906	176	73,062	183	22,415	69	24,182	61
9	COOLING WATER SYSTEM	24,563	62	24,761	62	24,676	62	10,168	31	11,360	29
10	ASH/SPENT SORBENT HANDLING SYS	22,254	56	21,643	54	21,132	53				
11	ACCESSORY ELECTRIC PLANT	25,373	64	25,614	64	25,600	64	18,140	56	19,034	48
12	INSTRUMENTATION & CONTROL	14,222	36	14,401	36	14,459	36	11,501	35	12,361	31
13	IMPROVEMENTS TO SITE	9,767	25	9,821	24	9,798	25	8,738	27	9,557	24
14	BUILDINGS & STRUCTURES	48,055	121	47,090	117	46,161	115	12,030	37	12,918	33
	TOTAL PLANT COST	**$448,840**	**1,129**	**$471,489**	**1,173**	**$467,774**	**1,170**	**$170,968**	**524**	**$182,227**	**461**

In addition to the TPC cost level, the TPI and TCR were determined. TPI at date of startup includes escalation of construction costs and allowance for funds used during construction (AFDC), formerly called "interest during construction," over the construction period. TPI is computed from the TPC, which is expressed on an "overnight" or instantaneous construction basis. For the design and construction cash flow, a variable expenditure rate was assumed, with all expenditures taking place at the end of the year.

The TCR includes all capital necessary to complete the entire project. TCR consists of TPI, prepaid royalties, preproduction (or startup) costs, inventory capital, initial chemical and catalyst charge, and land cost:

- Preproduction costs are intended to cover operator training, equipment checkout, major changes in plant equipment, extra maintenance, and inefficient use of fuel and other materials during plant startup. They are estimated as follows:
  - One month fixed operating costs -- operating and maintenance labor, administrative and support labor, and maintenance materials.
  - One month of variable operating costs at full capacity (excluding fuel) -- includes chemicals, water, and other consumable and waste disposal charges.
  - 25 percent of full capacity fuel cost for one month -- covers inefficient operation that occurs during the startup period.
  - Two percent of TPI -- covers expected changes and modifications to equipment that will be needed to bring the plant up to full capacity.
- Inventory capital is the value of inventories of fuel, other consumables, and byproducts, which are capitalized and included in the inventory capital account. The inventory capital is estimated as follows: solid fuel inventory is based on full-capacity operation for 30 days, but natural gas is excluded from inventory capital.
- Inventory of other consumables (excluding water) is normally based on full-capacity operation at the same number of days as specified for the fuel. In addition, an allowance of 1/2 percent of the TPC equipment cost is included for spare parts.

- Initial catalyst and chemical charge covers the initial cost of any catalyst or chemicals that are contained in the process equipment (but not on storage, which is covered in inventory capital). No value is shown because costs are minimal and included directly in the component equipment capital cost.
- Land cost is based on $1,500 per acre.

The TPI and TCR values are included in the economic results table at the end of this section.

Although the estimate is intended to represent a complete power plant, there are several qualifications/exclusions as follows:

- Sales tax is not included (considered to be exempt).
- Onsite fuel transportation equipment (such as barge tug, barges, yard locomotive, bulldozers) is not included.
- Allowances for site-specific conditions (such as piling, extensive site access, excessive dewatering, extensive inclement weather) are not included.
- Switchyard (transmission plant) is not included. The scope of the cost estimate includes the high voltage terminal of the main power transformer.
- Ash disposal facility is excluded, other than the storage in the ash-storage silos. (The ash disposal cost is accounted for in the ash disposal charge as part of consumable costs.)
- Royalties are not included.

9.2 PRODUCTION COSTS AND EXPENSES

The production costs or operating costs and related maintenance expenses (O&M) described in this section pertain to those charges associated with operating and maintaining the power plants over their expected life.

The costs and expenses associated with operating and maintaining the plant include:

- Operating labor

- Maintenance
  - Material
  - Labor
- Administrative and support labor
- Consumable
- Fuel cost

These costs and expenses are estimated on a reference year (January 1998) basis and then escalated to a first-year basis, in January 2005 dollars. The first-year costs assume normal operation and do not include the initial startup costs. The operating labor, maintenance material and labor, and other labor-related costs are combined and then divided into two components: fixed O&M, which is independent of power generation, and variable O&M, which is proportional to power generation. The first-year O&M cost estimate allocation is based on the plant capacity factor.

The other operating costs, consumables and fuel, are determined on a daily 100 percent operating capacity basis and adjusted to an annual plant operation basis. The inputs for each category of operating costs and expenses are identified in the succeeding subsections, along with more specific discussion of the evaluation processes.

9.3 COST OF ELECTRICITY (COE)

The revenue requirement method of performing an economic analysis of a prospective power plant has been widely used in the electric utility industry. This method permits the incorporation of the various dissimilar components for a potential new plant into a single value that can be compared to various alternatives. The revenue requirement figure-of-merit is COE levelized (reported on a 10^{th} year basis) coal pile-to-busbar cost of power expressed in ¢/kWh. The value includes the TCR, which is represented in the levelized carrying charge (sometimes referred to as the fixed charges), 10^{th} year fixed and variable operating and maintenance costs, 10^{th} year consumable operating costs, and the 10^{th} year fuel cost.

The principal cost and economics output for this study, the Capital Investment and Revenue Requirement Summary, is included in Appendix E and summarized in Table 9-3. This table presents key TPC values and other significant capital costs, reference year operating costs, maintenance costs, consumables, fuel cost, and the levelized constant dollar busbar COE.

TABLE 9-3

CASE COMPARISONS - SELECTED COST & FINANCIAL DATA

TECHNOLOGY:	GASIFICATION COMBINED CYCLE (IGCC)								FLUIDIZED BED	
CASE:	Destec 2 "F"		Destec-"G"		Destec-"H"		Transport Gasifier		2gPFBCw/Boost	
	Base Year $		Base Year $		Base Year $		Base Year $		Base Year $	
Base (Reference Year), January:	1998		1998		1998		1998		1998	
MWe(net):	543.2		349.2		427.7		398.1		379.2	
Net Plant Heat Rate-100% Load (Btu/kWh-HHV):	8,522		7,513		6,968		6,870		7,269	
Capacity Factor (equivalent @ 100% Load):	85		85		85		85		85	
BARE ERECTED COST (BEC)-$x1000	$534,667		$334,677		$363,220		$281,703		$287,411	
BEC $/KW	984		958		849		708		758	
TOTAL PLANT COST (TPC)-$x1000	$674,276		$429,256		$465,125		$382,559		$379,535	
TPC $/KW	1,241		1,229		1,087		961		1,001	
TOTAL CAPITAL REQUIREMENT (TCR)-$x1000	$765,615		$470,670		$510,175		$426,694		$417,135	
TCR $/KW	1,409		1,348		1,193		1,072		1,100	
FIXED O & M (base year)-$/kW	31.29		35.60		32.78		31.42		29.64	
VARIABLE O & M (base year)-¢/kWh	0.07		0.08		0.08		0.07		0.07	
OPERATION & MAINTENANCE COSTS-¢/kWh	**Reference**	**Levelized**	**Reference**	**Levelized**	**Reference**	**Levelized**	**Reference**	**Levelized**	**Reference**	**Levelized**
Fixed O & M	0.42	0.42	0.48	0.48	0.44	0.44	0.42	0.42	0.40	0.40
Variable O & M	0.07	0.07	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07
Consumables	0.09	0.09	0.11	0.11	0.10	0.10	0.09	0.09	0.21	0.21
By-product Credit & Emission Credits/Costs	-0.19	-0.19	-0.17	-0.17	-0.16	-0.16	-0.15	-0.15		
Fuel	1.07	0.92	0.94	0.81	0.87	0.75	0.86	0.74	0.91	0.79
TOTAL PRODUCTION COST	1.47	1.32	1.45	1.32	1.33	1.21	1.30	1.18	1.59	1.46
LEVELIZED CARRYING CHARGES (Capital)		2.56		2.44		2.16		1.94		1.99
LEVELIZED BUSBAR COST OF POWER-¢/kWh Levelized (10th.Year $)		**3.88**		**3.76**		**3.38**		**3.12**		**3.46**

NOTES:

TPC costs in Jan.1998 $

TCR costs include escalation for 2005 initial operation

1st.year O&M (Production) Costs in 2005 dollars

10th.year O&M & COE based on years 2005 to 2025 operation

Credits (byproduct & emission) excluded from baseline analysis

Capital Structure (constant dollars)	% of Total	Cost (%)
Equity	20	16.5
Debt	80	5.8

Weighted Cost of Capital (after tax basis)=6.2%

Levelized Carrying Charge Factor=13.5%

Project Book Life=20 years

Fuel Cost Basis:	Coal	Nat.Gas
Coal = Illinois #6 @ 11,666 Btu/lb		
Jan.1998 base price, $/MMBtu	1.26	2.70
Annual Fuel escalation, real (1996-2005)	-1.36%	0.04%
Annual Fuel escalation, real (2005-2025)	-1.07%	1.21%
General Annual escalation	0.00%	0.00%

Fuel Price and escalation based on analysis of AEO 1998 data

TABLE 9-3 (Cont'd)

CASE COMPARISONS - SELECTED COST & FINANCIAL DATA

TECHNOLOGY:	PULVERIZED COAL (PC)						Nat.GasCombined Cycle			
CASE:	Subcritical PC		Supercritical PC		Ultracritical PC		NGCC-"G"		NGCC-"H"	
	Base Year $		Base Year $		Base Year $		Base Year $		Base Year $	
Base (Reference Year), January:	1998		1998		1998		1998		1998	
MWe(net):	397.5		401.8		399.7		326.1		395.0	
Net Plant Heat Rate-100% Load (Btu/kWh-HHV):	9,077		8,568		8,251		6,743		6,396	
Capacity Factor (equivalent @ 100% Load):	85		85		85		65		65	
BARE ERECTED COST (BEC)-$x1000	$360,255		$379,761		$376,805		$137,531		$146,506	
BEC $/KW	906		945		943		422		371	
TOTAL PLANT COST (TPC)-$x1000	$448,840		$471,489		$467,774		$170,968		$182,227	
TPC $/KW	1,129		1,173		1,170		524		461	
TOTAL CAPITAL REQUIREMENT (TCR)-$x1000	$487,586		$512,167		$507,588		$183,149		$195,344	
TCR $/KW	1,227		1,275		1,270		562		495	
FIXED O & M (base year)-$/kW	22.80		23.41		23.37		10.40		10.35	
VARIABLE O & M (base year)-¢/kWh	0.05		0.06		0.06		0.10		0.10	
OPERATION & MAINTENANCE COSTS-¢/kWh	**Reference**	**Levelized**	**Reference**	**Levelized**	**Reference**	**Levelized**	**Reference**	**Levelized**	**Reference**	**Levelized**
Fixed O & M	0.31	0.31	0.31	0.31	0.31	0.31	0.18	0.18	0.18	0.18
Variable O & M	0.05	0.05	0.06	0.06	0.06	0.06	0.10	0.10	0.10	0.10
Consumables	0.17	0.17	0.29	0.29	0.16	0.16	0.04	0.04	0.03	0.03
By-product Credit & Emission Credits/Costs										
Fuel	1.14	0.98	1.08	0.93	1.04	0.89	1.82	1.94	1.73	1.84
TOTAL PRODUCTION COST	1.67	1.52	1.74	1.59	1.56	1.42	2.14	2.26	2.04	2.15
LEVELIZED CARRYING CHARGES (Capital)		2.22		2.31		2.30		1.33		1.17
LEVELIZED BUSBAR COST OF POWER-¢/kWh Levelized (10th.Year $)		**3.74**		**3.90**		**3.72**		**3.59**		**3.32**

NOTES:

TPC costs in Jan.1998 $

TCR costs include escalation for 2005 initial operation

1st.year O&M (Production) Costs in 2005 dollars

10th.year O&M & COE based on years 2005 to 2025 operation

Credits (byproduct & emission) excluded from baseline analysis

Capital Structure (constant dollars)	% of Total	Cost (%)
Equity	20	16.5
Debt	80	5.8

Weighted Cost of Capital (after tax basis)=6.2%

Levelized Carrying Charge Factor=13.5%

Project Book Life=20 years

Fuel Cost Basis:	Coal	Nat.Gas
Coal = Illinois #6 @ 11,666 Btu/lb		
Jan.1998 base price, $/MMBtu	1.26	2.70
Annual Fuel escalation, real (1996-2005)	-1.36%	0.04%
Annual Fuel escalation, real (2005-2025)	-1.07%	1.21%
General Annual escalation	0.00%	0.00%
Fuel Price and escalation based on analysis of AEO 1998 data		